EXPERIMENT # 4: Combinational Logic Circuits

Name: _____Date: _____

Equipment/Parts Needed:

5V DC Power Supply
Digital Trainer (Logic Probe)
Breadboard
DIP Switch
7400 NAND gate
7402 NOR gate
7404 Inverter
7408 AND gate
7432 OR gate

Objective:

- Many times in the application of Boolean algebra, you have to reduce a particular expression to its simplest form or change its form to a more convenient one to implement the expression most efficiently. The approach taken in this lab is to use the basic laws, rules, DeMorgan's theorems, and theorems of Boolean algebra to manipulate and simplify an expression.
- After performing this experiment, you will be able to simplify a combinational logic circuit to its minimum (simplest) form.

Discussion:

- The basic rules and laws of both Boolean Algebra and DeMorgan's theorem are used to reduce a given expression to a simplified form so that the number of gates are minimized to as far as possible to produce the same output.
- A **Truth Table** defines how a combination of gates will react to all possible input combinations.
- A Logic Probe is a piece of test equipment which displays the logic level at a point in the circuit. 0 to 0.8V = Logic 0 and lights the **L** indicator. 2.0V to 5.0V = Logic 1 and lights the **H** indicator. Invalid logic voltage levels light neither indicator.

Part 1:

1) Construct a circuit whose expression shown in Figure 4-1 using AND and OR gates.

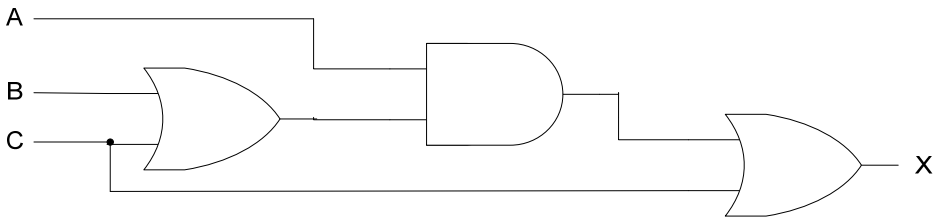

Figure 4-1 Logic Circuit for part 1.

2) Find the Boolean equation for Figure 4-1.

3) Fill in the Truth table and measure the voltages of V_A, V_B, V_C, and V_X for each input/output.

Voltages measured			**Truth Table**				
V_A (V)	V_B (V)	V_C (V)	**A**	**B**	**C**	**X**	V_X (V)
			0	**0**	**0**		
			0	**0**	**1**		
			0	**1**	**0**		
			0	**1**	**1**		
			1	**0**	**0**		
			1	**0**	**1**		
			1	**1**	**0**		
			1	**1**	**1**		

Table 4-1 Truth table and volts measured for input/output for Figure 4-1

4) Simplify the expression and circuit for Figure 4-1. Verify that the simplified circuit is equivalent to the original by showing that the truth tables are identical.

4-1) The simplified expression is:

4-2) Draw the simplified circuit here.

4-3) Develop the truth table for the simplified circuit and measured the voltage for each input/output.

Voltages measured			**Truth Table**				
V_A (V)	V_B (V)	V_C (V)	**A**	**B**	**C**	**X**	V_X (V)
			0	**0**	**0**		
			0	**0**	**1**		
			0	**1**	**0**		
			0	**1**	**1**		
			1	**0**	**0**		
			1	**0**	**1**		
			1	**1**	**0**		
			1	**1**	**1**		

Table 4-2 Truth table and volts measured for input/output for the simplified circuit of Figure 4-1

4-4) Verify the truth tables Table 4-1 and Table 4-2 and show they both are identical.

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Part 2:

1) Construct a circuit whose expression shown in Figure 4-2 using NAND, NOR, and AND gates.

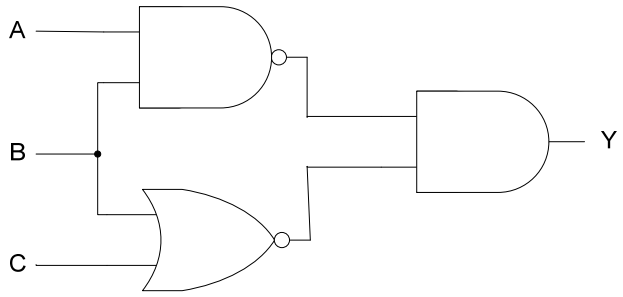

Figure 4-2 Logic Circuit for part 2.

2) Find the Boolean equation for Figure 4-2.

3) Fill in the Truth table and measure the voltages of V_A, V_B, V_C, and V_Y for each input/output.

Voltages measured			**Truth Table**				
V_A (V)	V_B (V)	V_C (V)	**A**	**B**	**C**	**Y**	V_Y (V)
			0	**0**	**0**		
			0	**0**	**1**		
			0	**1**	**0**		
			0	**1**	**1**		
			1	**0**	**0**		
			1	**0**	**1**		
			1	**1**	**0**		
			1	**1**	**1**		

Table 4-3 Truth table and volts measured for input/output for Figure 4-2

4) Then simplify the expression and circuit, and verify that the simplified circuit is equivalent to the original by showing that the truth tables are identical.

4-1) The simplified expression is:

4-2) Draw the simplified circuit here.

4-3) Develop the truth table for the simplified circuit and measured the voltage for each input/output

Voltages measured			**Truth Table**				
V_A (V)	V_B (V)	V_C (V)	**A**	**B**	**C**	**Y**	V_Y (V)
			0	**0**	**0**		
			0	**0**	**1**		
			0	**1**	**0**		
			0	**1**	**1**		
			1	**0**	**0**		
			1	**0**	**1**		
			1	**1**	**0**		
			1	**1**	**1**		

Table 4-4 Truth table and volts measured for input/output for the simplified circuit of Figure 4-2

4-4) Verify the truth tables Table 4-3 and Table 4-4 and show they both are identical.

Instructor's Signature:_____, Date: _____

Questions/Report:

1. **Why is Boolean algebra used for combinational logic circuits?**

2. **What are three laws for Boolean algebra? Answer with simple examples.**

3. **Why is De Morgan's theorem important in the simplification of Boolean equation?**

4. **Using De Morgan's theorem, you can prove that a NAND gate is equivalent to an _____ (OR or AND) gate with inverted inputs.**

5. **Using De Morgan's theorem, you can prove that a NOR gate is equivalent to an _____ (OR or AND) gate with inverted inputs.**